NEURAL NETWORK CONTROLLER FOR DC MOTOR USING MATLAB APPLICATION

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This Thesis is Part Fulfillment of the Requirement for a Bachelor
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DECLARATION

“I declare that this thesis entitled ‘Neural Network Controller for DC Motor using Matlab Application’ is the result of my own research except as cited in references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree”,

Signature : …………………………….

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Date : November 8, 2008

DEDICATION

Special dedicated to my family, my friends, my fellow colleague,
and to all faculty members

For all your care, support, and believe in me.

Sincerely;
Norazlina binti Ab. Rahman

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ABSTRACT

The purpose of this study is to control the speed of direct current (DC) motor with Artificial Neural Network (ANN) controller using MATLAB application. The Artificial Neural Network Controller will be design and must be tune, so the comparison between simulation result and experimental result can be made. The scopes includes the simulation and modeling of direct current (DC) motor, implementation of Artificial Neural Network Controller into actual DC motor and comparison of MATLAB simulation result with the experimental result. This research was about introducing the new ability of in estimating speed and controlling the permanent magnet direct current (PMDC) motor. In this project, ANN Controller will be used to control the speed of DC motor. The ANN Controller will be programmed to control the speed of DC motor at certain speed level. The data from ANN Controller is sent to the DC motor through an interface circuit or a medium called DAQ card. The sensor will be used to detect the speed of motor. Then, the result from sensor is fed back to ANN Controller to find the comparison between the desired output and measured output.

ABSTRAK

Tujuan utama kajian ini adalah untuk mengawal kelajuan *Direct Current (DC) Motor*, di mana *Artificial Neural Network (ANN)* akan menjadi pengawal kelajuan utama dan diaplikasi menggunakan MATLAB. *Artificial Neural Network Controller* akan direka bentuk dan harus disesuaikan nilai komponennya supaya perbezaan di antara keputusan simulasi dapat dibandingkan dengan keputusan eksperimen. Skop tugasan kajian ini termasuklah simulasi dan model *direct current (DC) motor*, perlaksanaan *Artificial Neural Network Controller* ke dalam DC motor yang sebenar dan perbandingan keputusan simulasi MATLAB dengan keputusan eksperimen. Kajian ini adalah untuk memperkenalkan keupayaan baru dalam menaksir dan mengawal kelajuan *Permanent Magnet Direct Current (PMDC) motor*. Di dalam projek ini, *ANN Controller* akan digunakan untuk mengawal kelajuan DC motor. *ANN Controller* juga akan diprogramkan untuk mengawal kelajuan motor melalui simulasi MATLAB pada kadar kelajuan yang telah ditetapkan. Data daripada *ANN Controller* akan dihantar kepada DC motor melalui litar penghubung atau medium yang dikenali sebagai Kad DAQ. Alat pengesan (*Encoder*) akan mengesan tahap kelajuan motor. Selepas itu, keputusan daripada alat pengesan akan di suap kembali kepada *ANN Controller* untuk mencari perbandingan di antara keputusan yang kehendaki dengan keputusan sebenar eksperimen.

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LIST OF SYMBOLS/ABBREVIATIONS

ANN	-	Artificial Neural Network
BLDC	-	Brushless Direct Current
DAQ	-	Data Acquisition Card
DC	-	Direct Current

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CHAPTER 1

INTRODUCTION

1.1 General Introduction to DC Motor Drives

1.1.1 DC Motor Drives

Conventional direct current electric machines and alternating current induction and synchronous electric machines have traditionally been the three cornerstones serving daily electric motors needs from small household appliances to large industrial plants.

Recent technological advances in computing power and motor drive systems have allowed an even further increase in application demands on electric motors. Through the years, even AC power system clearly winning out over DC system, DC motors still continued to be significant fraction in machinery purchased each year.

There were several reasons for the continued popularity of DC motors. One was the DC power systems are still common in cars and trucks. Another application for DC motors was a situation in which wide variations in speed in needed. Most DC machines are like AC machines in that they have AC voltages and currents within them, DC machines have a DC output only because a mechanism exists that converts the internal AC voltages to DC voltages at their terminals.

The greatest advantage of DC motors may be speed control. Since speed is directly proportional to armature voltage and inversely proportional to the magnetic flux produced by the poles, adjusting the armature voltage and/or the field current will change the rotor speed. Today, adjustable frequency drives can provide precise speed control for AC motors, but they do so at the expense of power quality, as the solid-state switching devices in the drives produce a rich harmonic spectrum. The DC motor has no adverse effects on power quality.

1.2 Permanent Magnet Direct Current (PMDC) motor

1.2.1 Introduction

In a Permanent Magnet motor a coil of wire (called the armature) is arranged in the magnetic field of a permanent magnet in such a way that it rotates when a current is passed through it. Now, when a coil of wire is moving in a magnetic field a voltage is induced in the coil - so the current (which is caused by applying a voltage to the coil) causes the armature to rotate and so generate a voltage. It is the nature of cause and effect in physics that the effect tends to cancel the cause, so the induced voltage tends to cancel out the applied voltage.

Voltage is electrical pressure. Current is electrical flow. Pressure tends to cause movement, or flow so an electrical pressure is a force which moves electricity or an 'electromotive force' (EMF). The induced voltage caused by the armature's movement is a 'back EMF' where 'back' because it tends to cancel out the applied voltage so that the actual voltage or pressure across the armature is the difference between the applied voltage and the back EMF.

The value of the back EMF is determined by the speed of rotation and the strength of the magnet such that if the magnet is strong the back EMF increases and if the speed increases, so too does the back EMF.

1.2.2 Classification of PM Motor

In Permanent Magnet motors, it falls into two categories: PM DC motors and PM AC motors. PM DC motors are separately excited DC motors with permanent magnets as the excitation source. In industry, they are widely used as control motors, often in precision applications such as computer disk drives. Permanent Magnet motor classification can be based on control strategy, which produces more classification of PM motors, the brushless DC (BLDC) motor and conventional permanent magnet synchronous motor.

1.2.3 Brushless DC (BLDC) Motor

A brushless DC motor (BLDC) is a synchronous electric motor which is power-driven by direct-current electricity (DC) and which has an electronically controlled commutation system, instead of a mechanical commutation system based on brushes. In such motors, current and torque, voltage and rpm are linearly related. In BLDC motor, there are two sub-types used which are the Stepper Motor type that may have more poles on the stator and the Reluctance Motor.

In a conventional (brushed) DC motor, the brushes make mechanical contact with a set of electrical contacts on the rotor or also called the commutator, forming an electrical circuit between the DC electrical source and the armature coil-windings. As the armature rotates on axis, the stationary brushes come into contact with different sections of the rotating commutator. The commutator and brush system form a set of electrical switches, each firing in sequence, such that electrical-power always flows through the armature coil closest to the permanent magnet that is used as a stationary stator.

In a BLDC motor, the electromagnets do not move; but, the permanent magnets rotate and the armature remains static. This gets around the problem of how to transfer current to a moving armature. The method which is the brush-system/commutator assembly is replaced by an electronic controller is used. The controller performs the same power distribution found in a brushed DC motor, but using a solid-state circuit rather than a commutator/brush system.

In this motor, the mechanical "rotating switch" or commutator/brush gear assembly is replaced by an external electronic switch synchronized to the rotor's position. Brushless motors are typically 85-90% efficient, whereas DC motors with brush gear are typically 75-80% efficient. BLDC motors also have several advantages over brushed DC motors, including higher efficiency and reliability, reduced noise, longer lifetime caused by no brush erosion in it; elimination of ionizing sparks from the commutator, and overall reduction of electromagnetic interference (EMI). With no windings on the rotor, they are not subjected to centrifugal forces, and because the electromagnets are located around the perimeter, the electromagnets can be cooled by conduction to the motor casing, requiring no airflow inside the motor for cooling. This means that the motor's internals can be entirely enclosed and protected from dirt or other foreign matter. [2]

The maximum power that can be applied to a BLDC motor is exceptionally high, limited almost exclusively by heat, which can damage the magnets. BLDC's main disadvantage is higher cost, which arises from two issues. First, BLDC motors require complex electronic speed controllers to run. Brushed DC motors can be regulated by a comparatively trivial variable resistor (potentiometer or rheostat), which is inefficient but also satisfactory for cost-sensitive applications. Second, many practical uses have not been well developed in the commercial sector.

BLDC motors are considered to be more efficient than brushed DC motors. This means that for the same input power, a BLDC motor will convert more electrical power into mechanical power than a brushed motor, mostly due to the absence of friction of brushes. The enhanced efficiency is greatest in the no-load and low-load region of the motor's performance curve. Under high mechanical loads, BLDC motors and high-quality brushed motors are comparable in efficiency. Brushless DC motors are commonly used where precise speed control is necessary, as in computer disk drives or in video cassette recorders, the spindles within CD, and etc. [2]

1.3 Problem Statement

When commerce with DC motor, the problem come across with it are efficiency and losses. In order for DC motor to function efficiently on a job, it must have some special controller with it. Thus, the Artificial Neural Network Controller will be used.

There are too many types of controller nowadays, but ANN Controller is chosen to interface with the DC motor because in ANN, Non-adaptive control systems have fixed parameters that are used to control a system. These types of controllers have proven to be very successful in controlling linear, or almost linear, systems.

1.4 Problems encountered and solutions

Problem encountered:-

i) Control of DC motor speed;

ii) Interface of DC motor with software (MATLAB/SIMULINK);

iii) To acquire data from the DC motor

Solutions:-

i) Use of ANN controller to the system;

ii) Implementation of DAQ card to the control board;

iii) Use of encoder from the DC motor to the control board;

1.5 Objectives

The objective of the Artificial Neural Network Controller Design for DC motor using MATLAB an application is it must control the speed of DC motor with Artificial Neural Network controller using MATLAB application which the design of the ANN controller is provided and can be tune. Each of the experimental result must be compared to the result of simulation, as a way to attain the closely approximation value that can be achieved in this system.

1.6 Scopes

The scopes that will be figure out in this research are:

i) Simulation and Modeling of DC motor;
ii) Implementation of ANN controller to actual DC motor;
iii) Comparison of MATLAB simulation result with the experimental result.

CHAPTER 2

LITERATURE REVIEW

2.1 Artificial Neural Network Controller

2.1.1 Introduction

Nowadays, the field of electrical power system control in general and motor control in particular has been researching broadly. The new technologies are applied to these in order to design the complicated technology system. One of these new technologies is Artificial Neural Network (ANNs) which based on the operating principle of human being nerve neural. It is composed of a large number of highly interconnected processing elements (neurons) working in unison to solve specific problems. ANNs, like people, learn by example. An ANN is configured for a specific application, such as pattern recognition or data classification, through a learning process. Learning in biological systems involves adjustments to the synaptic connections that exist between the neurons. This is true of ANNs as well.

There are a number of articles that use ANNs applications to identify the mathematical DC motor model. Then, this model is applied to control the motor speed. The inverting forward ANN with two input parameters for adaptive control of DC motor ANNs are applied broadly because all the ANN signal are transmitted in one direction, the same as in automatically control system, the ability of ANNs to learn the sample, the